Chapter 3. Water Quality Monitoring

Water quality monitoring from 1997 through 2000 continued according to the amended protocol implemented in 1996 (Lehman and others 2001). Discrete samples were taken monthly at 11 representative sites (Figure 3-1). Data were recorded within one hour of high slack tide and the time of each sample was recorded to the nearest five minutes of Pacific Standard Time. A qualitative description of weather conditions was recorded for each cruise. Samples were analyzed for the 14 physical and chemical parameters shown in Table 3-1. This chapter presents the results for seven water quality parameters. The complete database is available online at http://www.bdat/index.html

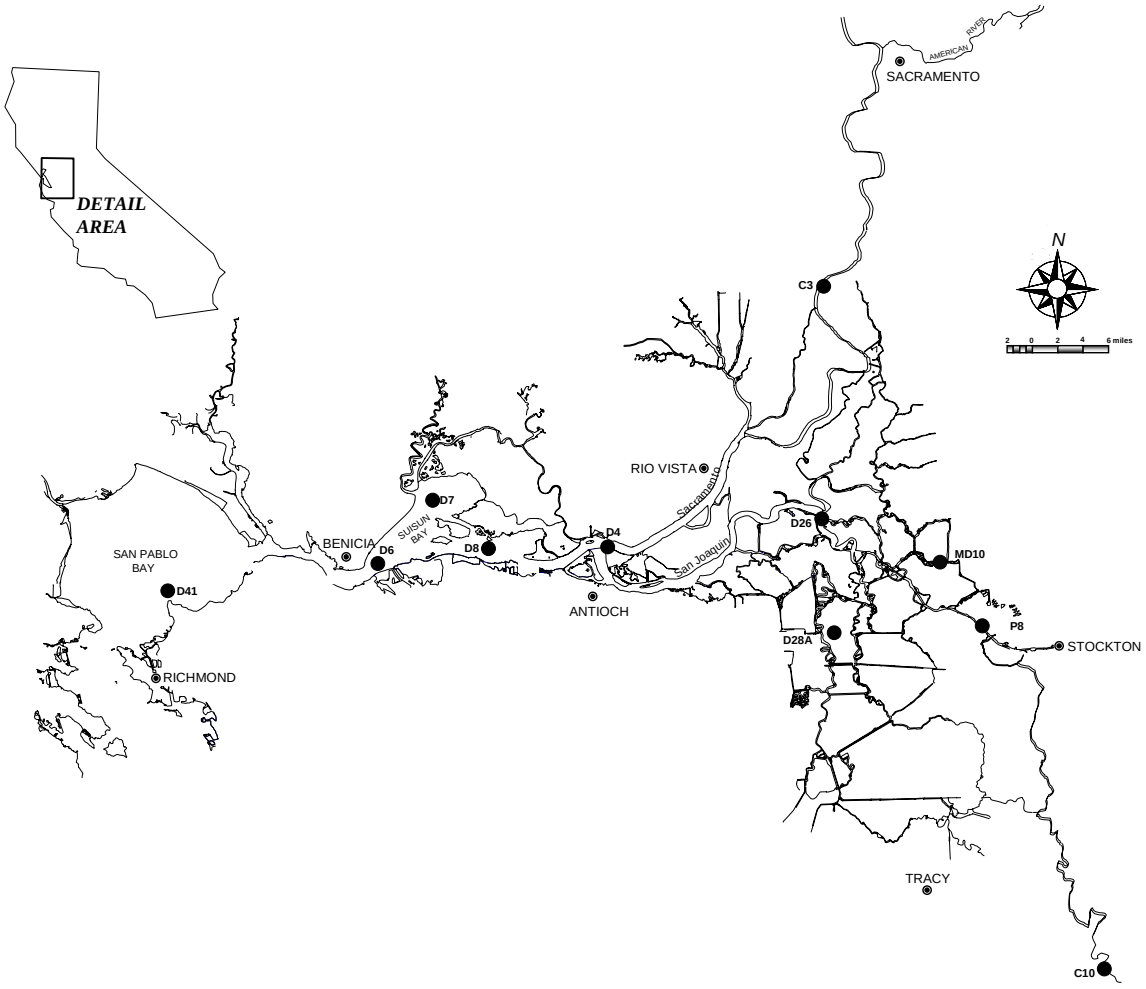

Figure 3-1 Map of sampling sites

Table 3-1 Water quality parameters measured

Water temperature (°C)
Secchi disk depth (m)
Dissolved oxygen (mg/L)
Specific conductance (µS/cm)
Dissolved inorganic nitrogen (mg/L)
Volatile suspended solids (mg/L)
Orthophosphate (mg/L)
Silica (mg/L)
Total dissolved solids (mg/L)
Total suspended solids (mg/L)
Chloride (mg/L)
Kjelahl nitrogen (mg/L)
Total phosphorus (mg/L)
Dissolved organic nitrogen (mg/L)

As shown in Table 3-2, 11 sampling sites are used in this study to represent eight regions of the Bay-Delta system. The results from a single sampling site are used to represent water quality conditions in six of these eight regions. The south Delta and Suisun Bay regions, however, are represented by averaged values of two and three stations, respectively.[1]

Table 3-2 Sampling sites and regions

Region	Sampling Sites
Lower Sacramento River	D4
Lower San Joaquin River	D26
North Delta	C3
Central Delta	D28a
East Delta	MD10
South Delta	C10 & P8
Suisun Bay	D6, D7, & D8
San Pablo Bay	D41

[1] An exception to this protocol exists for Secchi disk depth measurements for the south Delta region. Secchi disk depth measurements for this region are represented by a single sampling at Site P8, as no Secchi disk depth measurements are made at sampling Site C10.

Parameters Measured

Water Temperature

Water temperature was measured in degrees Centigrade (°C) with a YSI thermistor. The thermistor measured the temperature of water collected by pump at a depth of 1 meter.

Recorded temperatures varied seasonally, being significantly lower in winter than in the summer. A temperature minima of 7.1 °C was recorded in the lower San Joaquin River region during January 1999, and a maxima of 26.9 °C was recorded in the central Delta region in July 1998. All regions showed a similar seasonal pattern, with temperature minima occurring in approximately January of each year. Temperature maxima were recorded from July to September. Lowest annual mean temperatures occurred in the Suisun and San Pablo Bay regions (Figure 3-2).

Secchi Disk Depth

Water transparency was measured to the nearest centimeter using a 20-cm diameter Secchi disk attached to a 2.5-m rod marked in cm. Water transparency was recorded as the average of (1) the depth at which the disk could no longer be seen as it was lowered into the water column from the shaded side of the vessel, and (2) the depth at which it was seen as it was raised.

Secchi disk depth ranged from a low of 0.15 m in the lower Sacramento River in February 1998, to a high of 1.88 m in San Pablo Bay in May 1997. Secchi disk depth varied seasonally and inter-annually. Both the lowest seasonal and inter-annual variations were observed in Suisun Bay and the lower Sacramento River regions. These regions also had the lowest mean annual Secchi disk depths. Both the highest annual and inter-annual variations were observed in San Pablo Bay and the north Delta regions. The long-term increase in transparency data noted in previous reports (Lehman 1996) was not discernable in the 1997-2000 data (Figure 3-3).

Dissolved Oxygen

Dissolved oxygen (DO) was measured using the modified Winkler iodometric method described in Standard Methods (APHA 1998). A sample aliquot was collected from a through-hull pump or from a grab sample, at a depth of 1 meter. The samples were collected in 300-ml glass-stoppered bottles and immediately analyzed onboard.

During the period of study, DO concentrations ranged from a minimum of 4.6 mg/L in the south Delta in July 1997, to a maximum of 11.4 mg/L in the lower Sacramento River in January 1999. Strong seasonal trends were evident in all regions, with DO concentrations decreasing during the summer months and rising in the winter months. DO levels between years generally were within a range of about 2 mg/L in most regions, and followed consistent seasonal patterns. The most variable measured DO concentrations were found in the south Delta region. (Figure 3-4).

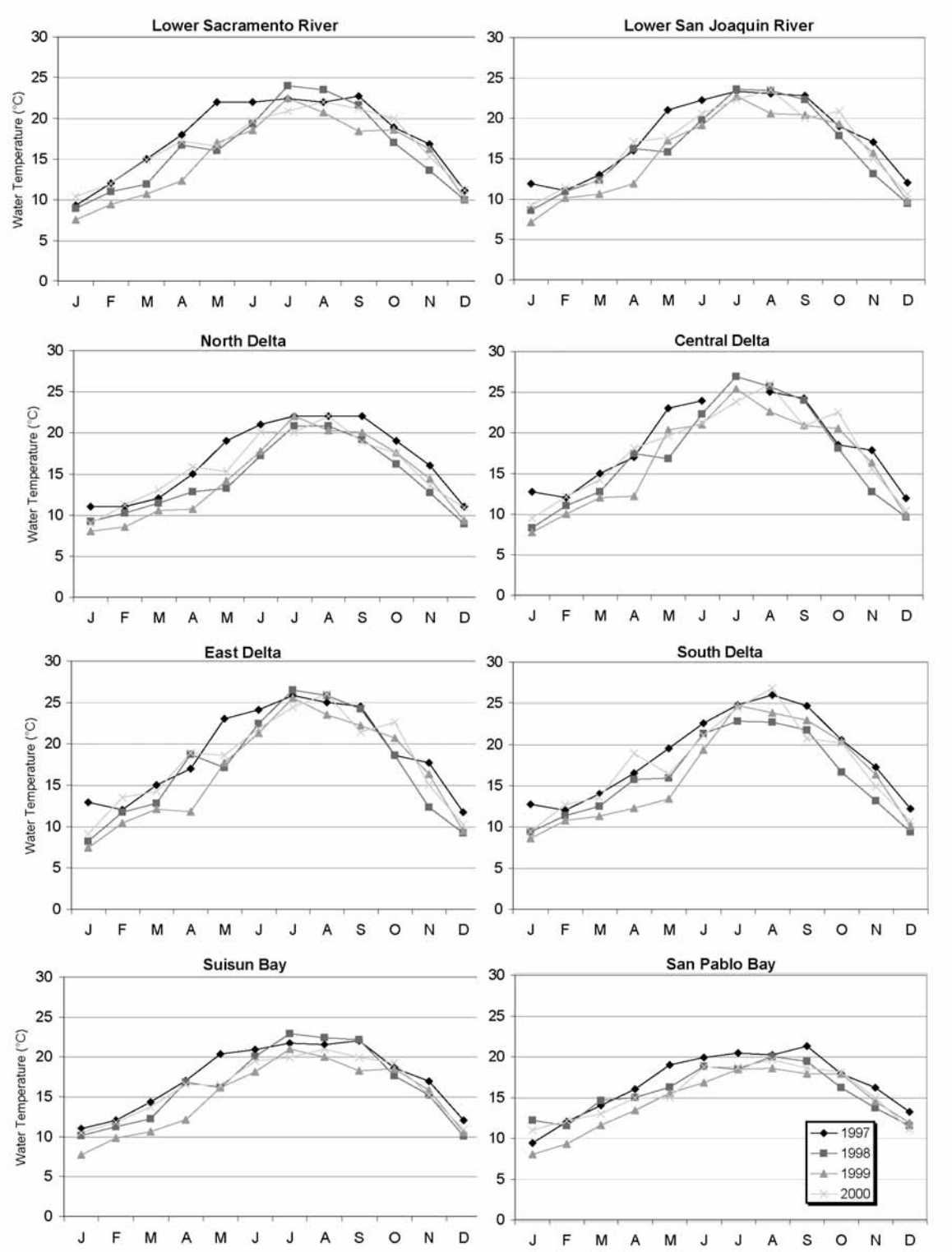

Figure 3-2 Monthly water temperatures (°C) at eight upper San Francisco Estuary regions, 1997-2000

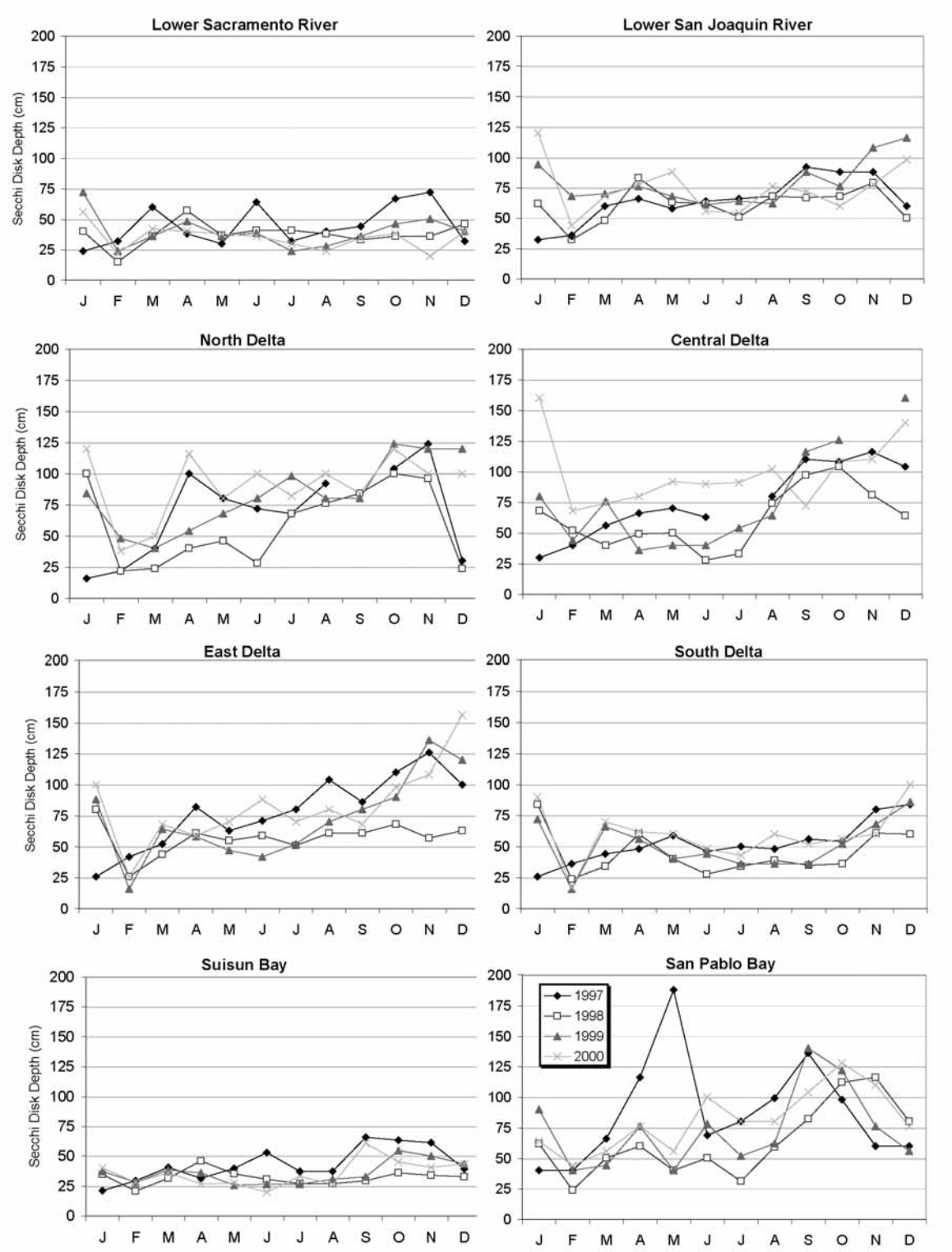

Figure 3-3 Monthly Secchi disk depths (cm) at eight upper San Francisco Estuary regions, 1997-2000

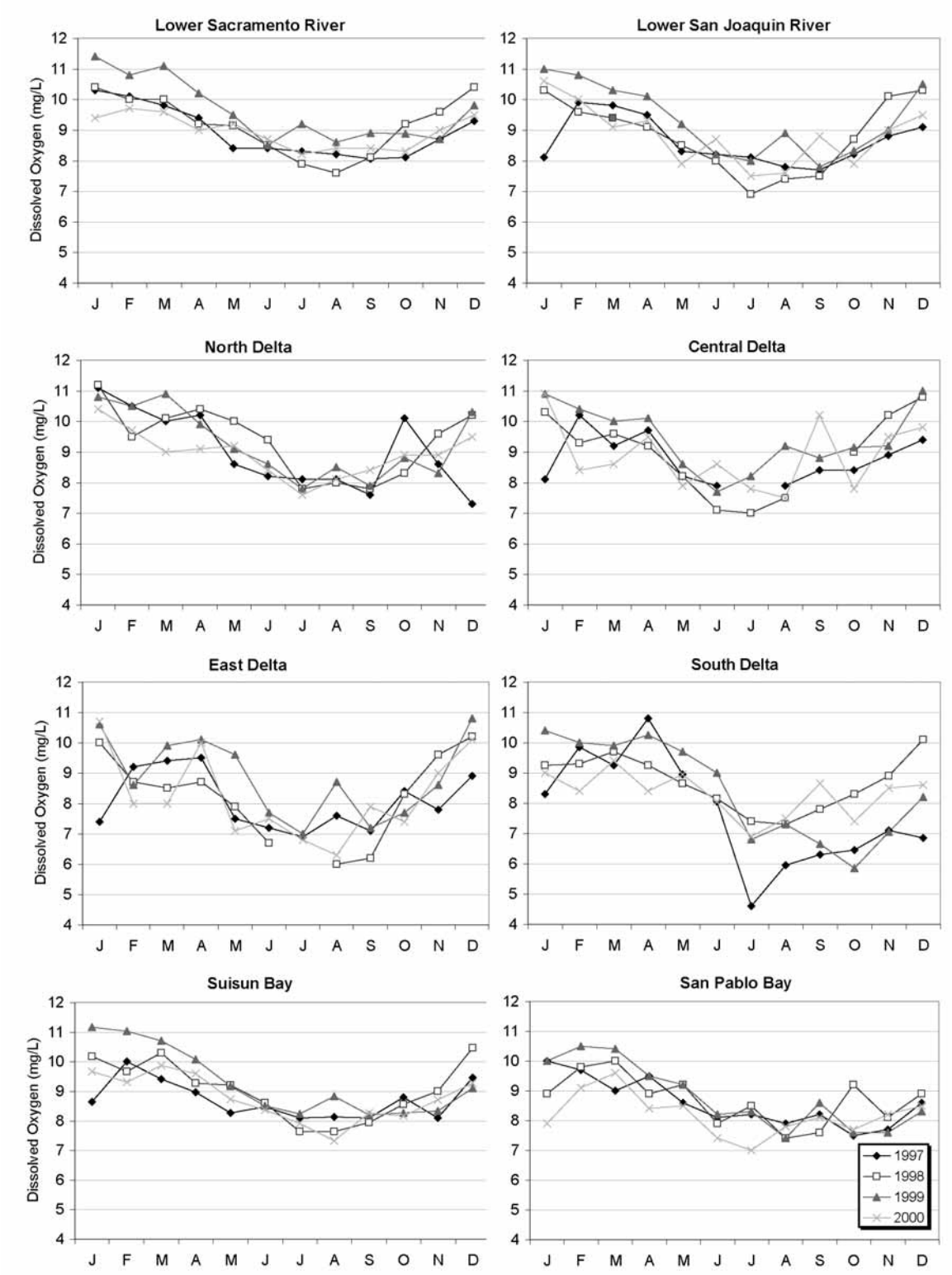

Figure 3-4 Monthly DO levels (mg/L) at eight upper San Francisco Estuary regions, 1997-2000

Specific Conductance

Specific conductance, an indicator of salinity, was determined from samples collected from a through-hull pump at a 1-meter depth. The samples were analyzed for specific conductance using a Beckman RC-20 conductivity bridge equipped with manual temperature compensation. Measured values were temperature compensated to 25 °C.

Specific conductance in the upper San Francisco Estuary ranged from a low of 68 µS/cm in the north Delta in January 1997 to a high of 44,349 µS/cm in San Pablo Bay in November 1999. Specific conductance generally increased from east to west and was affected by inflows and tidal action. Maximum values occurred in the late summer and fall when flows through the Delta were low and marine intrusion was greatest. Relatively high inflows throughout the study period resulted in little seasonal variation in the north and east Delta regions and in the lower San Joaquin River region. Overall, specific conductance showed similar patterns for all years of the study period. (Figure 3-5).

Dissolved Inorganic Nitrogen

Dissolved inorganic nitrogen (DIN) is a measure of total ammonia (NH_3), nitrate (NO_3), and nitrite (NO_2), the nitrogen forms immediately available for assimilation by phytoplankton. DIN was measured by first pumping water samples from a 1-meter depth into new, rinsed polyethylene bottles. The samples were then filtered through a pre-washed 0.45-micron pore size membrane filter. The filtrate was immediately frozen and later transported to Bryte Laboratory[2] for analysis. The minimum reporting limit[3] for nitrogen was 0.01 mg/L. The methods of analysis used for measuring DIN are listed in Table 3-3.

DIN concentrations ranged from 0.08 mg/L in the east Delta region in August 1997, to 5.2 mg/L in the south Delta region in December 1999. In several regions, particularly the east Delta, concentrations were highest during winter and spring, the period when seasonal runoff is greatest. Concentrations in most regions generally were lowest in August and September, when water temperatures and phytoplankton growth were highest and inflows were lowest. Concentrations in the south Delta showed the greatest degree of variability both seasonally and inter-annually. By contrast, DIN concentrations in the San Pablo and Suisun Bay regions varied little on a seasonal or inter-annual basis (Figure 3-6).

Table 3-3 Nutrient analysis methods

Substance	Method	Ref. Method #
Ammonia	Colormetric, automated phenate method	350.1
Nitrate plus nitrite	Colormetric, automated cadmium reduction	353.2
Orthophosphate	Colormetric, automated ascorbic acid method	365.1

(Environmental Protection Agency 1983)

[2] Bryte Chemical Laboratory, Department of Water Resources, 1450 Riverbank Road, West Sacramento, CA 95605

[3] The reporting limit is a laboratory determined value that is three to ten times the method detection limit.

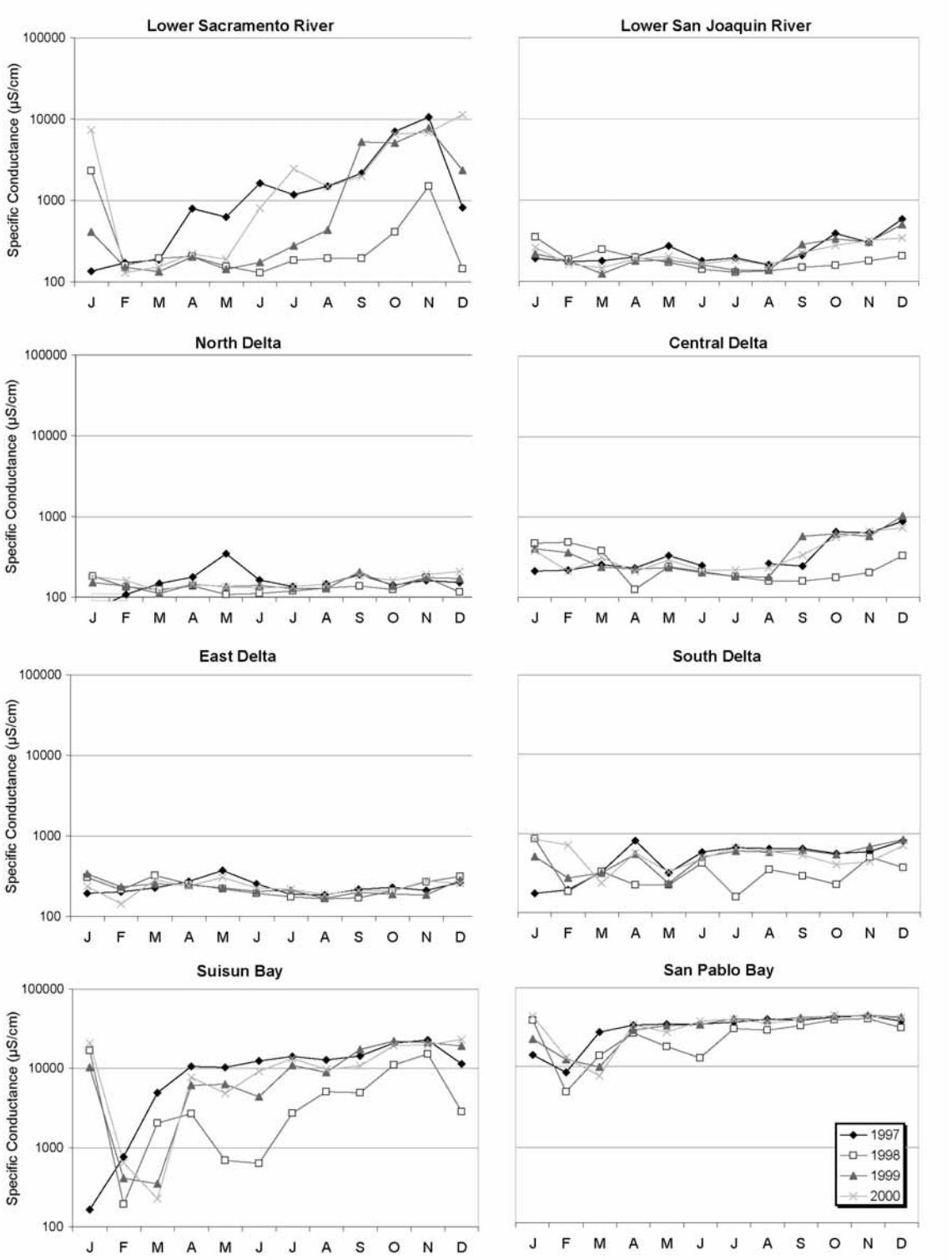

Figure 3-5 Monthly specific conductance measurements (µS/cm) at eight upper San Francisco Estuary regions, 1997-2000

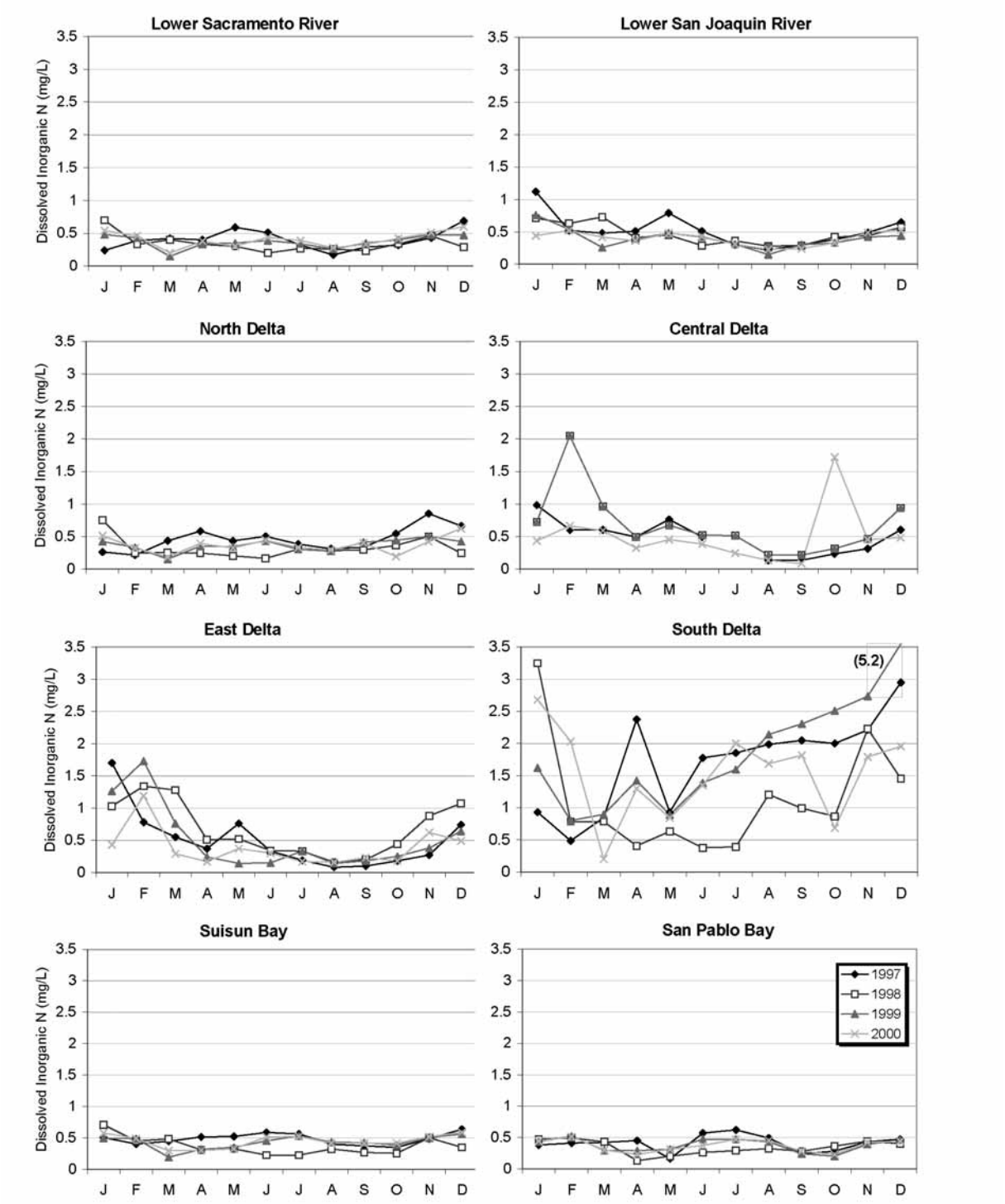

Figure 3-6 Monthly dissolved inorganic nitrogen levels (mg/L) at eight upper San Francisco Estuary regions, 1997-2000

Orthophosphate

Orthophosphate is soluble inorganic phosphate, the phosphorus compound most immediately available for assimilation by phytoplankton. Orthophosphate concentrations were measured by first collecting sample aliquots from a 1-meter depth into new, rinsed polyethylene bottles. The samples were then filtered through a pre-washed membrane filter with a 0.45-micron pore size. The filtrate was immediately frozen and later transported to Bryte Laboratory for analysis. The minimum reporting limit for orthophosphate is 0.01 mg /L. The method of analysis for measuring orthophosphate is listed in Table 3-3.

Measured orthophosphate concentrations ranged from a low in several locations of 0.02 mg/L, to a high of 0.36 mg/L in the Delta in February 1999. The north Delta, lower Sacramento River, lower San Joaquin River, east Delta, and Suisun Bay regions all had minimum concentrations of 0.02 mg/L. The central and south Delta regions had slightly higher concentrations at 0.03 mg/L. Since natural levels of orthophosphate in freshwaters usually range from 0.005 to 0.05 mg/L (Dunne and Leopold 1978), these levels likely represent approximate minimum baseline, or natural levels in the regions. The highest regional orthophosphate concentrations occurred during the winter months in the east and south Delta regions. These levels were approximately three times higher than maximum concentrations recorded for the same period in the downstream regions. In the downstream regions of Suisun Bay and San Pablo Bay, orthophosphate concentrations rose in the spring and summer months. Seasonal variation was lowest in the lower Sacramento River and north Delta (Figure 3-7).

Volatile Suspended Solids

The measurement of volatile suspended solids (VSS) provides a relative indicator of the amount of organic matter present in the water sample. Water samples for VSS analysis were taken from aliquots collected from a depth of 1 meter, stored in polyethylene bottles, and refrigerated at 4 °C until analyzed at Bryte Laboratory. Samples were analyzed for VSS according to EPA Method 160.4 (EPA 1983). The minimum reporting level for VSS in these analyses was 1.0 mg/L.

VSS levels fell below minimum detection levels (<1 mg/L) in several regions from 1997 through 2000, and reached a high of 35 mg/L in the lower Sacramento River in February 1998. The western bays were generally more variable than the other regions, due possibly to tidal influences or increased resuspension of shallow bottom sediments. VSS levels in the central Delta region were consistently higher than the levels in the other regions (Figure 3-8).

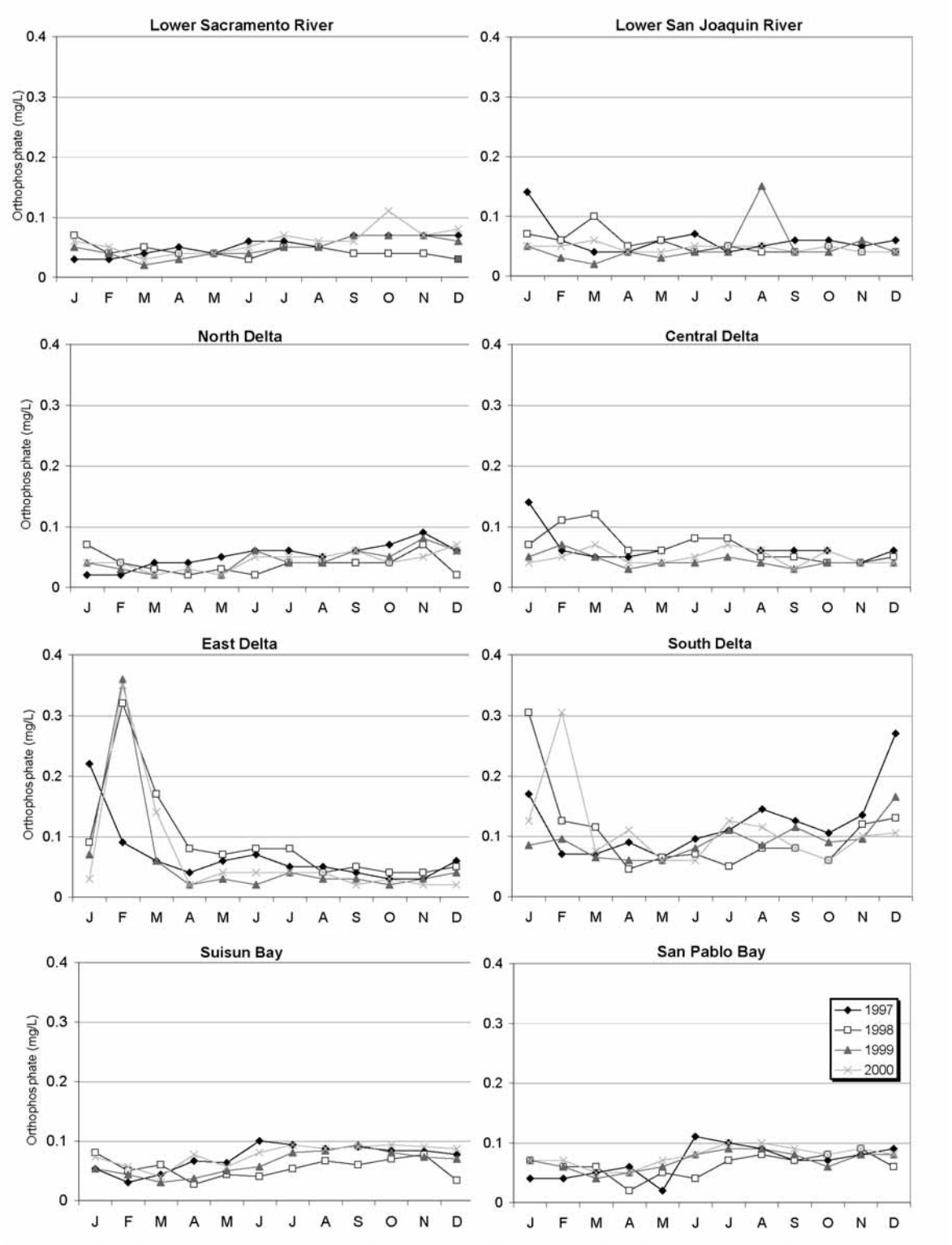

Figure 3-7 Monthly orthophosphate levels (mg/L) at eight upper San Francisco Estuary regions, 1997-2000

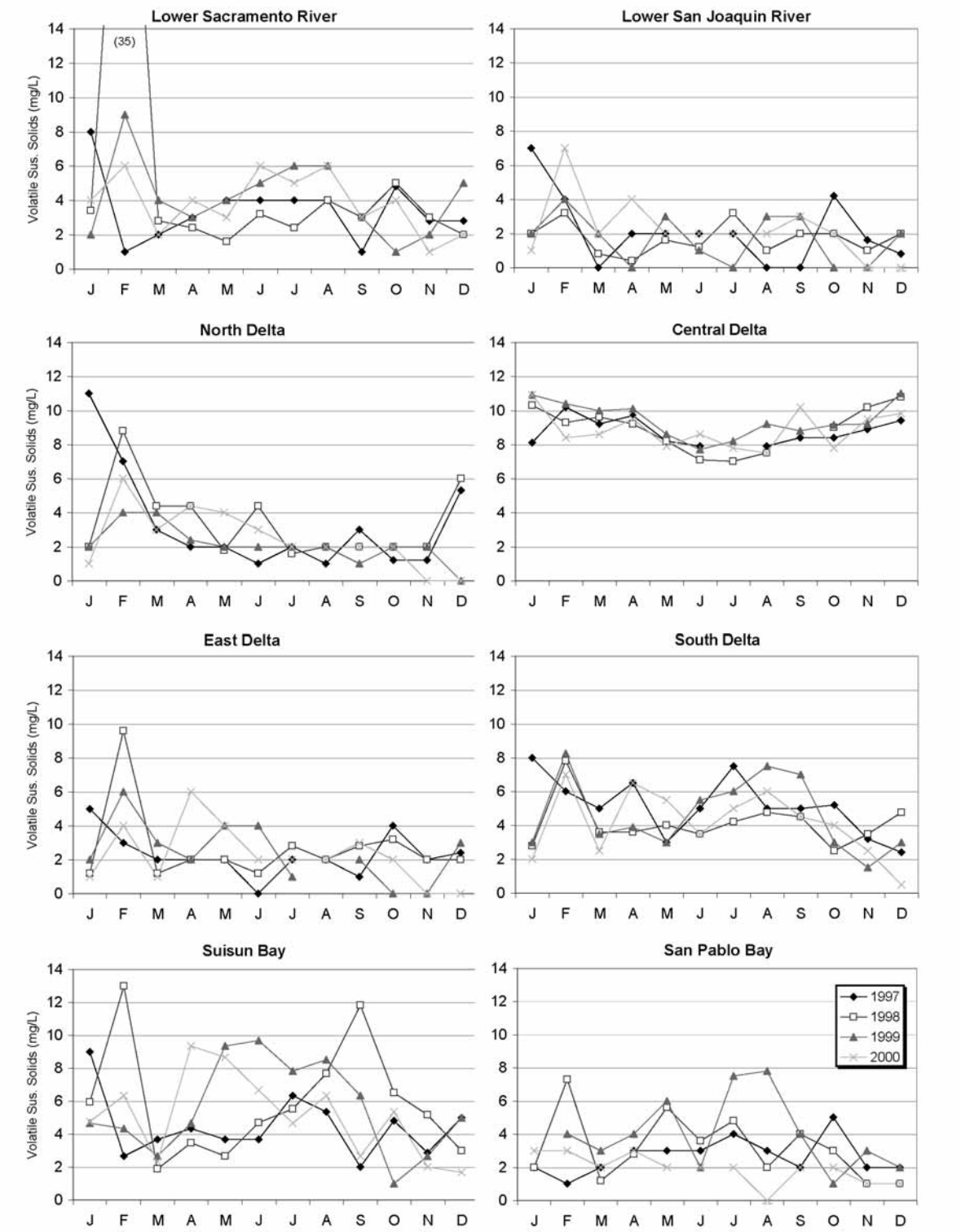

Figure 3-8 Monthly volatile suspended solids levels (mg/L) at eight upper San Francisco Estuary regions, 1997-2000